ACCIDENTS WAITING TO HAPPEN
THE DOWNWIND TURN

Soon after airplanes were invented, pilots began having accidents they blamed on "downwind turns." The cause was usually due to the pilot shifting his speed reference from the cockpit airspeed indicator to looking at how fast objects on the ground were passing by. If he perceived that he was speeding up, the logical action was to throttle back--sometimes to such a low airspeed that the wing stalled, often with disastrous results.

Can it happen to us?

Since a rotor does not stall at low speeds, helicopter pilots have not had exactly the same problem. But a related one--loss of directional control--has been reported under similar circumstances.

A study inspired by such incidents was the subject of a American Helicopter Society paper by Kelly McCool and Dr. David Haas of the Navy's David Taylor Model Basin. Their primary motivation was to explain cases of "unanticipated right yaw" (URY) on the Navy's Kaman SH-2 helicopters.

Some of these incidents resulted in two or more revolutions about the vertical axis before the pilot was able to regain control. Other people call the same problem "loss of tail rotor effectiveness" (LTE).

The scenario

SH-2 pilots reported that the trouble occurred during low-speed turns to downwind. The helicopter is often used for search and rescue missions at sea, and this is where the maneuver can be encountered. In a typical scenario, a pilot spots something floating on the water and starts a low-speed circling maneuver to get a better look.

During this maneuver, he transfers his speed reference from his airspeed indicator to the surface of the sea. Flying at a constant "seaspeed" produces a variable airspeed. For instance, if there is a 30-knot wind and the pilot maintains a constant, 40-knot seaspeed in a 360^{o} turn, the airspeed will vary from 10 to 70 knots, with large changes in main-rotor torque.

And assuming the ground track is a perfect circle to obtain maximum visibility, large sideslip angles would be required during the cross-wind portions of the maneuver. All these changes might catch the pilot unawares if his attention is focused primarily on the search.

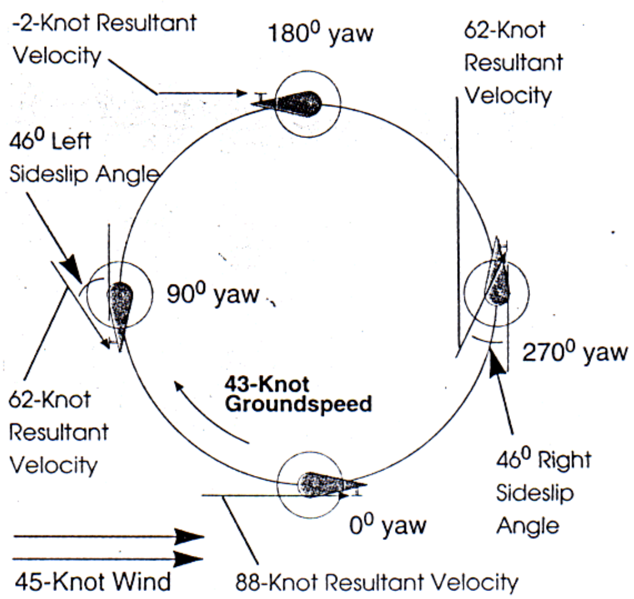
The study

Previous flight tests of an SH-2 determined that there was no deficiency in the tail rotor's capability at steady speeds up to 35 knots in all directions. This laid to rest any concern about tail-rotor stall or unusual vortex-ring characteristics.

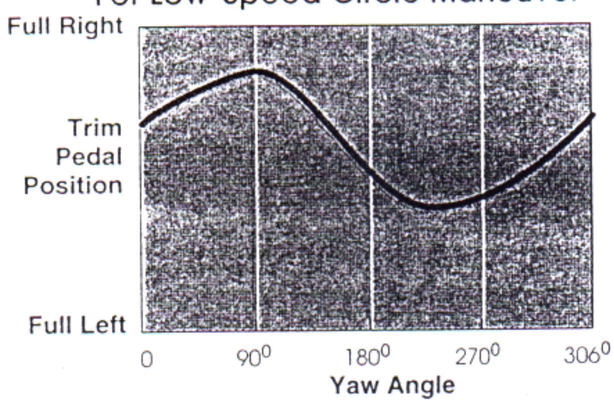
McCool and Haas developed a computer program concentrating on the yaw degree of freedom to study the problem. The program has rather sophisticated equations for tail-rotor thrust, including the effects of main-rotor wake and the proximity of the vertical stabilizer.

They chose to examine the extreme case of a 43-knot circle to the right in a 45-knot wind as shown in the first figure on the next page. The conditions include large changes in airspeed, main-rotor torque, and sideslip angles. The computer results (second figure on the next page) indicated an adequate margin existed and no problem was evident. So the investigators started asking, "What if?"

The Ground-Referenced, Low-Speed Circle Maneuver



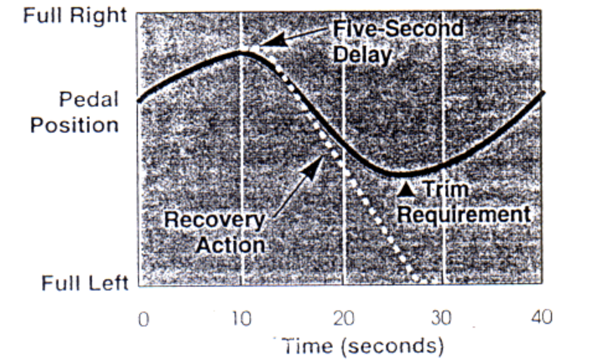
Calculated Pedal Position Required For Low-Speed Circle Maneuver



Second-guessing the pilot

They examined what would happen if the pilot delayed reversing the pedal position by five seconds as he went from left crosswind (90º), where a lot of right pedal was required because of the sideslip, to downwind. They assumed that once recognizing his mistake, he would move the pedals all the way to the left stop about twice as fast as for the steady condition as shown below.

Assumed Pilot Pedal Motion, Including Delay



Despite this extreme--but belated--action, the simulation showed control would still be lost. The yaw rate to the right would increase from the steady 7º per second to 70º or more, and the aircraft would spin completely around more than once before stopping.

And in conclusion

Since this result agrees with the pilot reports, it seems to be a valid explanation of unanticipated right yaws. It is also a warning to pilots to not be fooled by the speed objects on the ground or sea are passing by during a downwind turn.

The accepted recovery technique is to hold full left pedal, use forward cyclic pitch to gain air speed, and reduce collective if at a safe altitude.

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